SURGICAL TREATMENT OF PATIENTS WITH WOLFF-PARKINSON-WHITE SYNDROME AND ASSOCIATED EBSTEIN'S ANOMALY

Ebstein's anomaly is the most common congenital heart disease associated with the Wolff-Parkinson-White syndrome. Between November 1973 and March 1993, we surgically treated 42 patients with Wolff-Parkinson-White syndrome and Ebstein's anomaly. The patients' ages ranged from 5 months to 59 years (mean 35.3 ± 14.0 years). There were a total of 52 accessory pathways, 48 of which were located in the right (65%) or posteroseptal (29%) area. A left-sided accessory pathway was seen in only two patients (3.8%). Division of all right-sided accessory pathways was done during normothermic cardiopulmonary bypass with the heart beating; cryocoagulation was applied together with scalpel dissection of the atrioventricular groove. Division of the left-sided accessory pathways was done with the use of cold potassium cardioplegic arrest. Thirty-five of these patients underwent tricuspid valve operation for Ebstein's anomaly and 11 of them underwent tricuspid valve replacement with a bioprosthesis. All 52 accessory pathways were successfully divided, although two patients required reoperation because of tachycardia caused by accessory pathways in different positions. Three hospital deaths (7.1%) occurred. There were no late deaths during the follow-up period (mean 94.3 ± 52.4 months), but two patients required repeat tricuspid operation because of progression of the tricuspid regurgitation. Because no repeat operations were required during long-term follow-up in patients who underwent valve repair or valve replacement, correction should be indicated in some patients. (J THORAC CARDIOVASC SURG 1995;110:1702-7)

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Ebstein's anomaly is the most common congenital cardiac anomaly associated with Wolff-Parkinson-White (WPW) syndrome.[1] The clinical course in patients with this combination is diverse and depends on the degree of severity of Ebstein's anomaly and associated arrhythmias.[2] Concerning this pathologic combination[3-9] there have been several electrophysiologic and surgical reports including those by Danielson and colleagues[10] and Pressley and colleagues,[11] but the long-term results of surgical treatment for this combination remain unclear. The purpose of this study was to evaluate the surgical treatment in 42 patients who were followed up for up to 20 years to extend our initial observations regarding this combination.[12]

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Patients and methods

Between November 1973 and March 1993, 455 patients underwent surgical division of the accessory pathway (ACP) for treatment of WPW syndrome at our institutes (Kanazawa University School of Medicine and Toyama Medical and Pharmaceutical University). Of these patients, 42 had associated Ebstein's anomaly. The patients' ages ranged from 5 months to 59 years (mean 35.3 ± 14.0 years). The findings in these 42 patients were compared with those in the 413 patients without Ebstein's anomaly. The type and history of arrhythmias and number and location of ACPs, as well as the effective refractory period of antegrade ACPs, cycle length of reentrant tachycardias, and the shortest R-R interval during atrial fibrillation, were routinely examined (Table I). Fourteen patients

Table I. *Patient characteristics and electrophysiologic features*

	Ebstein's anomaly		
	Present (n = 42)	*Absent (n = 413)*	*p Value*
Mean age at operation (yr)	35.3 ± 14.0	37.5 ± 16.0	NS
Duration of arrhythmia (yr)	15.5 ± 12.1	12.4 ± 10.7	NS
History of cardiac arrest	3 (7.1%)	11 (2.7%)	NS
History of direct cardioversion	17 (40%)	127 (31%)	NS
Documented AF	24 (57%)	222 (54%)	NS
Postoperative AF	2 (5.2%)	42 (10%)	NS
Documented AVRT	38 (91%)	357 (87%)	NS
Shortest R-R interval during AF (msec)	216 ± 42	227 ± 51	NS
ERP of antegrade ACP (msec)	284 ± 37	276 ± 42	NS
Mean cycle length during AVRT (msec)	344 ± 58	330 ± 57	NS
Multiple pathways	10 (24%)	35 (8.5%)	<0.01
Total number of ACPs	52	451	
Location of ACP			
Left	2 (3.8%)	267 (59%)	<0.01
Posteroseptal	15 (29%)	48 (11%)	<0.01
Right	33 (63%)	124 (27%)	<0.01
Anteroseptal	2 (3.8%)	12 (2.7%)	NS

AF, Atrial fibrillation; *AVRT,* atrioventricular tachycardia; *ERP,* effective refractory period.

(33%) with mild Ebstein's anomalies had New York Heart Association (NYHA) functional class I or II symptoms. In 12 of these patients, the Ebstein's anomaly was not suspected by the physicians who referred the patients to us and mild anomaly was diagnosed in our institution during the preoperative echocardiographic assessment. Twenty-eight patients (67%) had moderate to severe Ebstein's anomaly with NYHA class III or IV symptoms and all of them had moderate or severe tricuspid regurgitation.

Surgical technique. After a median sternotomy, epicardial mapping was done to estimate the location of the ACP.[13] Division of all right-sided ACPs, including those in the posterior septum, was done during normothermic cardiopulmonary bypass with the heart beating. Before a right atriotomy was done, the heart was briefly fibrillated to obtain closure of a patent foramen ovale or an atrial septal defect. The heart was then defibrillated, and a supraannular atrial incision was made 2 mm above the true anulus of the tricuspid valve. The supraannular atrial incisions for the right posterior or posteroseptal ACPs were extended from the coronary sinus to the anteroinferior commisure of the tricuspid valve. Dissection was done between the underlying fat tissue and the ventricular muscle. Closure of the atrial incision, tricuspid valvular operation, and division of left-sided ACPs were done with the use of cold potassium cardioplegic arrest.

Of the 35 patients who underwent tricuspid valve operation for Ebstein's anomaly (Table II), 24 underwent Hardy's procedure: tricuspid valve repair and plications of atrialized right ventricles.[9, 14] The other 11 patients underwent tricuspid valve replacements; a Hancock porcine bioprosthesis* was used in five patients and a Carpentier-Edwards bioprosthesis† in six. Warfarin anticoagulation was initiated after removal of the chest tube. All patients received warfarin for up to 3 months after implantation and thereafter it was discontinued.

*Johnson & Johnson Cardiovascular, King of Prussia, Pa.

†Baxter Healthcare Corp., Edwards Division, Santa Ana, Calif.

Table II. *Surgical procedures (n = 42)*

	No.
Division of accessory pathway	42
Repeat ACP division	2
Tricuspid valve operation	35
Hardy's procedure*	24
Tricuspid valve replacement	11
Additional procedure	19
Closure of ASD	10
Closure of PFO	8
Replacement of ascending aorta and aortic valve replacement	1

ASD, Atrial septal defect; *PFO,* persistent foramen ovale.

*Tricuspid valve repair with plication of atrialized right ventricle.

Other associated cardiovascular abnormalities were observed in 19 patients, and those were corrected simultaneously. The procedures included 10 closures of secondum-type atrial septal defect, 8 closures of patent foramen ovale, and one replacement of the aortic valve and ascending aorta.[15]

Patient follow-up was done by maintaining direct contact with them or with their physicians. Follow-up was available for all patients, resulting in a 100% rate of completion.

Statistical methods. Data are expressed as mean plus or minus standard deviation. Univariate analysis was done with Student's t test and χ^2 test was used for comparison between groups. The probability of various factors influencing coexistence of Ebstein's anomaly was assessed by logistic regression analysis. Actuarial curves for event-free survival and death were generated by the method of Kaplan and Meier. The influence of various factors on risk

Table III. *Results of logistic regression analysis for coexistence of Ebstein's anomaly*

Variables	*Odds ratio*	*95% Confidence limits*		*p Value*
		Lower	*Upper*	
AVRT	1.560	0.497	4.895	0.46
Duration of arrhythmia	1.034	1.005	1.064	0.02
History of cardiac arrest	3.095	0.719	13.326	0.13
History of DC	1.319	0.641	2.715	0.45
No. of ACPs	2.264	1.105	4.639	0.03

AVRT, Atrioventricular tachycardia; *DC,* direct cardioversion.

of mortality was assessed by the Cox proportional hazards model. Odds ratios were quoted with 95% confidence intervals, with statistical significance at at least the 5% level being inferred.

Results

Clinical electrophysiologic characteristics. There was no significant difference in the clinical and electrophysiologic characteristics between the patients with and without Ebstein's anomaly (Table I). ACP distribution is also shown in this table. In the group of patients with Ebstein's anomaly, 10 patients (24%) had multiple pathways. Of 52 ACPs, 48 were located in the right (65%) or right posteroseptal (29%) area, whereas left-sided, right lateral, or right anteroseptal ACPs were seen in only two patients (3.8%). In patients without Ebstein's anomaly the most common location of ACPs was the left side. The difference in these distribution patterns between the patient groups was statistically significant.

Multivariate logistic analysis demonstrated that the odds ratios of two factors, duration of arrhythmia and number of ACPs, were significant, suggesting their relevance to Ebstein's anomaly associated with WPW syndrome (Table III).

Early surgical results. In the patients with Ebstein's anomaly, three hospital deaths (7.1%) occurred. The cause of death in two patients, 40 and 57 years old, respectively, with preoperative NYHA class IV symptoms, was low cardiac output after division of ACPs and tricuspid valve replacement. The remaining death occurred in a 38-year-old woman with a history of open cardiac massage necessitated by cardiac arrest. She died 22 days after tricuspid valve replacement of occult cancer (histiocytoma) refractory to chemotherapy. In these three patients, both delta waves and atrioventricular reentrant tachycardia had disappeared postoperatively.

Late surgical results. All of the remaining patients were followed up. No late deaths occurred during the mean follow-up interval (mean 94.3 ± 52.4 months). During this period, four patients required a repeat cardiac operation. In two patients, reoperations were done because of recurrence of tachycardia caused by residual second ACPs 6 years and 4 months and 5 years and 1 month, respectively, after initial division of the ACPs. These ACPs were located in a different position from the initial ACPs. In one of the patients, plication was done because of mild tricuspid regurgitation in addition to second ACP division. Another patient, who initially had mild preoperative tricuspid regurgitation, required a tricuspid valve replacement 1 year and 7 months after the initial operation because of severe hypoproteinemia caused by progressive tricuspid regurgitation. The remaining patient required aortic valve replacement because of infective endocarditis 5 years and 1 month after the initial operation.

Eleven patients underwent tricuspid valve replacement with a xenograft because of tricuspid valve insufficiency caused by severe Ebstein's anomaly. During the follow-up period (mean 93.4 ± 59.4 months), no valve dysfunction, bleeding complication, or thromboembolic complication was noted and no reoperations were done.

Although two patients required reoperation because of tachycardia, after operation no recurrence of reentrant tachycardia was observed in any of the 39 patients. The postoperative prevalence of atrial fibrillation (5.1%, 2/39) was significantly decreased compared with the preoperative incidence (55%, 23/42). There were no patients with new atrial fibrillation. All 39 patients were free from the need for antiarrhythmic drugs and had functional class I or II symptoms at the time of the most recent follow-up.

Results of Kaplan-Meier analysis of overall survival probability in patients with and without Ebstein's anomaly from the time of operation are shown in Fig. 1. Factors that influenced overall mortality are shown in Table IV. Multivariate Cox

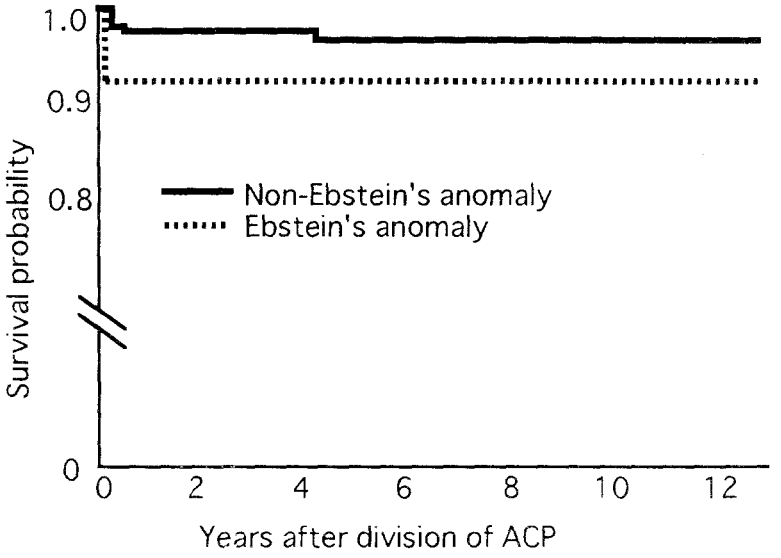

Fig. 1. Results of Kaplan-Meier analysis of overall survival probability from time of operation.

Table IV. *Results of Cox regression analysis for factors predictive of overall mortality*

		95% Confidence limits		
Variables	*Odds ratio*	*Lower*	*Upper*	*p Value*
Age	0.992	0.952	1.034	0.70
Combined disease	0.254	0.024	2.656	0.25
AVRT	2.739	0.296	25.331	0.38
AF	1.869	0.387	9.021	0.44
History of cardiac arrest	2.656	0.268	26.294	0.40
History of DC	1.247	0.322	4.831	0.75
No. of ACPs	1.964	0.494	7.806	0.34
Combined operation	6.866	1.650	28.569	0.01

AVRT, Atrioventricular tachycardia; *AF,* atrial fibrillation; *DC,* direct cardioversion.

analysis demonstrated that combined operation was a significant predictor of death.

Discussion

Location of ACPs. In this study, we documented the electrophysiologic characteristics of ACPs in patients with Ebstein's anomaly. In our patients, 92% (48/52) of ACPs were located on the right side or in the posteroseptal area. This finding is consistent with the hypothesis that Ebstein's anomaly originates from the incomplete separation of the right atrium and right ventricle during cardiogenesis.[16] Therefore it is possible that any part of the atrialized ventricle can be connected to the right atrium across the true anulus. This predominance of right posterior and right posteroseptal ACPs in patients with Ebstein's anomaly has been previously reported by us[15] and Smith and associates.[8] This finding may have clinical implications in terms of the selection of the surgical procedure. We performed complete detachment of the atrialized ventricle with use of a relatively large incision along the true anulus.[8]

Multiple ACPs. In 1980 we reported a case of successful simultaneous operation for WPW syndrome in a patient with multiple ACPs and tricuspid valve replacement.[7] We observed multiple ACPs in 24% of the patients with Ebstein's anomaly, which was more frequent than in patients without Ebstein's anomaly. A high prevalence of multiple ACPs is another electrophysiologic characteristic of this combination. In the patients of Pressley and associates,[11] multiple ACPs were observed at a much higher rate (50%) than in our patients. In our series, left-sided ACP was observed in two patients and accompanied one of the cases of multiple ACPs. Left-sided ACP is quite rare in patients with Ebstein's anomaly.[11, 17]

Atrial fibrillation. The propensity for atrial fibrillation is suspected to be increased in patients with combined heart disease.[15] However, in our series there was no significant difference between patients with and without Ebstein's anomaly in the percentage of atrial fibrillation or the shortest preexcited R-R interval during atrial fibrillation. It is believed that these features may reflect the inclusion of patients at high risk with atrial fibrillation in this study. It is suggested that some degenerative changes of the atrium may be present in patients with Ebstein's anomaly. These observations are in accordance with the results described in the previous report.[11]

Mild Ebstein's anomaly and sudden cardiac arrest. Three of our patients had histories of sudden cardiac arrest. However, this rate was not significantly different from that in the patients without Ebstein's anomaly who underwent operation for WPW. Two of the patients with histories of sudden cardiac arrest had associated mild Ebstein's anomaly that did not necessitate any additional operation. Rossi and Thiene[18] have reported similar cases of mild Ebstein's anomaly associated with sudden cardiac arrest. None of our patients with mild Ebstein's anomaly had significant hemodynamic alterations during sinus rhythm attributable to the malformation itself. Therefore, when nonpharmacologic procedures for this life-threatening arrhythmia are done it should be taken into consideration that patients with mild Ebstein's anomaly are at risk for the same severe arrhythmogenic events as patients with the classic forms of Ebstein's anomaly. Because unusual progression of tricuspid regurgitation was observed in three patients, a potential risk of reoperation was suggested.

Early mortality. In our patients, the surgical mortality rate was 7.1% (3/42). This indicates that a result comparable to that for patients with Ebstein's anomaly (5.3% to 25%)[10, 11, 19] was safely achieved in patients with Ebstein's anomaly associated with WPW syndrome. All three of the patients who died were in a relatively high age group (mean age 45 years), required tricuspid valve replacement, and had severely deteriorated preoperative cardiac function (NYHA class IV). The cause of death was thought to have been related not to the division of ACPs, but rather to the severity of the Ebstein's anomaly itself. These data suggest that early surgical intervention should be considered for patients with severe Ebstein's anomaly.

Long-term survival and morbidity. Excellent long-term results were obtained in our patients. The late mortality rate after operation for patients with Ebstein's anomaly has been reported to range from 5.6% to 15%.[10, 11, 19] The causes of death in these patients were sudden death and uncontrolled arrhythmias. As stated, two of our patients required repeat tricuspid valve operation because of progression of tricuspid insufficiency caused by Ebstein's anomaly. Because no repeat operation has been required during long-term follow-up in patients who underwent tricuspid valve repair or valve replacement at operation, correction of tricuspid regurgitation might be indicated in some patients. Currently, such patients might be treated by catheter ablation and followed up carefully for possible progression of tricuspid regurgitation.

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